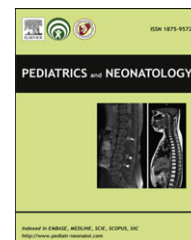


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ORIGINAL ARTICLE

Laparoscopic versus Open Appendectomy in the Management of All Stages of Acute Appendicitis in Children: A Retrospective Study

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Background: We conducted this study in order to evaluate whether laparoscopic appendectomy was an alternative therapeutic tool to open appendectomy for all stages of pediatric appendicitis.

Materials and Methods: Between January 2000 and November 2004, the charts of 177 children who underwent appendectomy by a single surgeon were reviewed. The patients were divided into open and laparoscopic appendectomy groups. Each group was subdivided into three stages: simple appendicitis, perforated appendicitis, and appendicitis with abscess. The age, gender, white blood cell count, absolute neutrophil count, C-reactive protein, operating time, duration of postoperative hospital stay, minor and major complications, and use of intravenous analgesia were recorded. Fisher's exact and Student's *t*-test were used for statistical analysis.

Results: There were fewer minor complications (9/32 vs. 0/20, $p = 0.009$) in perforated appendicitis stage and fewer major complications (9/26 vs. 1/24, $p = 0.011$) in appendicitis with abscess stage between open and laparoscopic appendectomy group. But surgery for each laparoscopic appendectomy group took longer to perform than for the corresponding open appendectomy group in each stage ($p < 0.05$). There was no significant difference in other data between corresponding groups in each stage.

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Conclusion: Laparoscopic appendectomy may be considered a better alternative to open appendectomy for children with perforated appendicitis and appendicitis with abscess.
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1. Introduction

Acute appendicitis is one of the most common indications for emergent surgical intervention in children. Laparoscopic appendectomy (LA) has been adopted by pediatric surgeons for several years, and most comparative studies of laparoscopic and open appendectomy have supported laparoscopic appendectomy as an alternative to open appendectomy (OA) in management of simple appendicitis.^{1,2} However, the role of LA in management of complicated appendicitis in children is controversial.^{3–7} We were particularly interested in the comparative outcomes of laparoscopy for complicated appendicitis. In this study, complicated appendicitis was further subdivided to perforated appendicitis and appendicitis with abscess on the basis of severity. The aim of this study was to evaluate whether LA was an alternative therapeutic tool to OA in all stages of pediatric appendicitis, including simple appendicitis, perforated appendicitis, and appendicitis with abscess.

2. Materials and Methods

Patients with principal International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes for appendicitis and age ≤ 18 years old were selected at the Kaohsiung Chang Gung Memorial Hospital between January 2000 and November 2004. These patients received appendectomy mostly because of common symptoms of acute appendicitis such as abdominal pain, especially over the right lower quadrant, fever, anorexia, nausea and vomiting (duration of symptoms < 5 days) as well as laboratory data including leukocytosis or high C-reactive protein (CRP). In addition, it was also a common indication for appendectomy that acute appendicitis was suspected highly by abdominal ultrasound or abdominal computed tomography (CT). If duration of symptoms had lasted for more than 5 days, the patient would receive empirical antibiotics treatment first and received interval appendectomy 12 weeks later. These patients receiving interval appendectomy were not enrolled in this study. Antibiotics were not used routinely before surgery. The usage of postoperative antibiotics was generally for 2–3 days in the simple appendicitis group and 5–7 days in the perforated appendicitis and appendicitis with abscess groups, in accordance with the patient's situation.

Clinical and laboratory information was obtained by reviewing patients' medical records, including the age, gender, white blood cell count (WBC), absolute neutrophil count (ANC), CRP, operating time, duration of postoperative hospital stay, minor and major complications, as well as the use of intravenous (IV) analgesia. All patients received OA during the duration before laparoscopy

became available in our hospital, and all patients received LA during the duration after laparoscopy was available in our hospital. However, when reviewing the charts, conversion from LA to OA was found in two patients with appendicitis with abscess due to severe inflammatory adhesions. These two patients were not enrolled in this study. Thus, these patients were divided by the procedure for appendectomy into two groups, OA and LA. Each group was further subdivided into three stages: simple appendicitis, perforated appendicitis, and appendicitis with abscess formation. These three stages were mainly divided by the description of operation notes, and the allocation was assisted by pathological report. Erythematous change and swelling of appendices were allocated into the groups of simple appendicitis. Gangrenous change and microscopic or gross perforation of appendices with / without minimal clear ascites were allocated into the groups of perforated appendicitis. Ruptured appendices with gross pus coating or turbid ascites or abscess formations with severe inflammatory adhesion were allocated into the groups of appendicitis with abscess. So there were a total of six subgroups in this study.

OA was performed by using a standard muscle-splitting approach in the right iliac fossa. The appendix was removed and stump was ligated. LA was performed by three-trocar technique (Karl Storz, Germany), the meso-appendix was controlled with laparoscopic bipolar cautery (Karl Storz, Germany), and the appendix base was tied with a single endoloop (Covidien, USA). The appendix was removed through the left iliac fossa port or the umbilical port. All appendices were examined histologically. All operations were performed by a single pediatric attending surgeon experienced in open and laparoscopic appendectomies.

The operating time was from finishing anesthesia to the last suture insertion, obtained in the operation notes. The hospital stay was the duration between the date for surgery and the date of discharge. The criteria for discharge of patient included no fever, eating well, and no tenderness over the abdomen in physical examination.

Minor complications were defined as abdominal distension / vomiting or paralytic ileus, development of an antibiotic-related rash, suture granuloma, as well as outpatient evaluation of complaints of nausea / vomiting, fever, pain or diarrhea. Major complications included wound infections, intra-abdominal abscess, as well as 30-day readmission for evaluation of complaints of nausea / vomiting, fever, pain or diarrhea.

The intravenous analgesia (meperidine or ketorolac for those over 2 years old and diphenhydramine for those less than 2 years old) was administered when patients voiced complaints of severe abdominal pain.

Statistical analysis was performed by Fisher's exact test and Student's *t*-test using the Statistical Package for the

Social Sciences (SPSS, Inc., Chicago, IL, USA) for comparison between OA and using LA in all stages of appendicitis, respectively. Data was expressed as mean \pm standard deviation. A p value of less than 0.05 was considered significant.

3. Results

3.1. Patients

We recruited 177 patients ≤ 18 years old who had appendicitis and received appendectomy from January 2000 to November 2004. There were 95 patients in OA groups, including 37 for simple appendicitis, 32 for perforated appendicitis, and 26 for appendicitis with abscess. There were 82 patients in LA groups, including 38 for simple appendicitis, 20 for perforated appendicitis and 24 for appendicitis with abscess. There were no statistical differences in age, gender, WBC, ANC, and CRP between each corresponding OA and LA groups in each stage of appendicitis (All $p > 0.05$; Tables 1,2,3).

3.2. Operating time

The median operating time of the entire LA group was significantly longer than that of the entire OA group for simple appendicitis, perforated appendicitis, appendicitis with abscess (69.6 ± 16.1 vs. 43.7 ± 17.8 ; 78.2 ± 25.7 vs. 49.2 ± 18.1 ; 80.5 ± 21.2 vs. 59.3 ± 34.7 , respectively, $p < 0.05$).

3.3. Hospital stay

No significant difference was found as to the duration of hospitalization between OA and LA groups for simple appendicitis, perforated appendicitis, and appendicitis with abscess (2.4 ± 1.1 vs. 2.7 ± 0.8 days; 4.1 ± 1.1 vs. 4.0 ± 1.6 days; 5.9 ± 2.9 vs. 5.3 ± 1.4 days, respectively, $p > 0.05$).

3.4. The use of intravenous analgesia

There was no significant difference regarding requirement for intravenous analgesia between OA and LA groups for simple appendicitis, perforated appendicitis, and appendicitis with abscess ($6/37$ vs. $6/38$; $12/32$ vs. $7/20$; and $12/26$ vs. $6/24$, respectively; $p > 0.05$).

3.5. Minor complications

As for the incidence of minor complications, there was no significant difference between OA and LA groups in the management of simple appendicitis and appendicitis with abscess ($3/37$ vs. $7/38$; $8/26$ vs. $12/24$, respectively; $p > 0.05$). But the incidence of minor complications in the LA group was much lower than that in the OA group in the management of perforated appendicitis ($0/20$ vs. $9/32$; $p < 0.05$).

3.6. Major complications

As for the incidence of major complications, there was no significant difference between OA and LA groups in the management of simple appendicitis and perforated appendicitis ($1/37$ vs. $2/38$; $5/32$ vs. $6/20$, respectively, $p > 0.05$). But the incidence of major complications in the LA group was far lower than that in the OA group in management of appendicitis with abscess ($1/24$ vs. $9/26$, $p < 0.05$).

4. Discussion

Published comparative studies describe the advantages of laparoscopic appendectomy over open appendectomy as to include less postoperative pain, shorter hospital stay, better cosmetics, and faster return to normal activity.^{4,8,9} However, the role of LA in management of complicated appendicitis in children is controversial.³⁻⁷

Most published comparative studies of laparoscopic and open appendectomy have divided appendicitis into two stages, simple or complicated appendicitis.¹⁰⁻¹²

Table 1 Comparison of parameters between open and laparoscopic appendectomy groups in management of simple appendicitis.

Parameters	Open ($n = 37$)	Laparoscopic ($n = 38$)	p
Age, mean \pm SD (years)	10.9 ± 3.4	12.4 ± 3.2	NS
Gender, No. (male/ female)	26/11	22/16	NS
WBC, mean \pm SD ($1000/\text{mm}^3$)	15.2 ± 5.5	14.1 ± 4.1	NS
ANC, mean \pm SD (%)	80.9 ± 9.3	80.6 ± 9.5	NS
C-reactive protein, mean \pm SD (mg/L)	34.7 ± 51.3	37.1 ± 50.9	NS
Operating time, mean \pm SD (minutes)	43.7 ± 17.8	69.6 ± 16.1	<0.05
Postoperative hospital stay, mean \pm SD (days)	2.4 ± 1.1	2.7 ± 0.8	NS
No., minor complications	3	7	NS
No., major complications	1	2	NS
No., with use of intravenous form analgesic	6	6	NS

NS = not significant; ANC = absolute neutrophil count.

Table 2 Comparison of parameters between open and laparoscopic appendectomy groups in management of perforated appendicitis.

	Open (n = 32)	Laparoscopic (n = 20)	p
Age, mean \pm SD (years)	9.4 \pm 3.3	9.6 \pm 3.6	NS
Gender, No. (male/ female)	21/11	12/8	NS
WBC, mean \pm SD (1000/mm ³)	16.1 \pm 4.5	18.5 \pm 5.8	NS
ANC, mean \pm SD (%)	85.2 \pm 5.5	86.2 \pm 8.2	NS
C-reactive protein, mean \pm SD (mg/L)	102.0 \pm 85.5	77.4 \pm 86.4	NS
Operating time, mean \pm SD (minutes)	49.2 \pm 18.1	78.2 \pm 25.7	<0.05
Postoperative hospital stay, mean \pm SD (days)	4.1 \pm 1.1	4.0 \pm 1.6	NS
No., minor complications	9	0	<0.05
No., major complications	5	6	NS
No., with use of intravenous form analgesic	12	7	NS

NS = not significant; ANC = absolute neutrophil count.

Nevertheless, the severity of complicated appendicitis can extend from perforated appendicitis to abscess formation, and even severe inflammatory adhesions. The technical difficulty of performing dissection and visualization of the appendix rests on the severity of complicated appendicitis. Hence, it is reasonable in our study to further subdivide complicated appendicitis into perforated appendicitis and appendicitis with abscess.

Operating time may be related to the skill and the variety of consultant pediatric surgeons and trainees. The OA and LA procedures in this study all were performed by a single experienced surgeon to decrease this variation. The mean operating time of laparoscopic appendectomy in this study was significantly longer than that of open appendectomy for all stages of acute appendicitis. The results corresponded to previous published comparative studies.^{4,13} This difference was due to the time needed to set up the equipment for laparoscopic appendectomy. In addition, the mean operating time increased as the complexity of the stage of appendicitis increased regardless of OA or LA group. But it would be improved when surgeon is more familiar with and skillful in the LA procedure.

The duration of hospital stay in this study also increased as the severity of appendicitis increased, regardless of the choice of OA and LA (Tables 1–3). The results differed from

these of some previous comparative studies^{13–17} but corresponded to those of some others.^{18,19} Therefore, there are multiple factors contributing to the duration of hospital stay, such as the severity of the inflammatory illness, the expectations of the patients and doctors, and the health insurance policy.

The requirement for intravenous analgesia was similar regardless of OA or LA group in the three stages of appendicitis, respectively. The requirement for intravenous analgesia also did not increase as the severity of appendicitis increased. Based on these observations, it seems reasonable to consider that the requirement for intravenous analgesia may be subjective to the patient's tolerance to pain.

Our study showed that the incidence of minor complications in LA group was less than that in the OA group in the management of perforated appendicitis (Table 2), mainly abdominal distention / vomiting or paralytic ileus (77%), as shown in Table 4.

In addition, our study also showed that the incidence of major complications in the LA group was also less than those in the OA group in the management of appendicitis with abscess (Table 3). Among these major complications in the OA group in the management of appendicitis with abscess, wound infection was 55.5%, 30-day readmission was 33.3%, and intra-abdominal abscess was 11.1% (Table 4). In the

Table 3 Comparison of parameters between open and laparoscopic appendectomy groups in management of appendicitis with abscess.

Parameters	Open (n = 26)	Laparoscopic (n = 24)	p
Age, mean \pm SD (years)	9.3 \pm 3.6	9.4 \pm 3.7	NS
Gender, No. (male/ female)	18/8	15/9	NS
WBC, mean \pm SD (1000/mm ³)	15.3 \pm 5.7	14.3 \pm 6.2	NS
ANC, mean \pm SD (%)	84.1 \pm 6.5	80.1 \pm 9.5	NS
C-reactive protein, mean \pm SD (mg/L)	145.7 \pm 93.7	103.5 \pm 59.5	NS
Operating time, mean \pm SD (minutes)	59.3 \pm 34.7	80.5 \pm 21.2	<0.05
Postoperative hospital stay, mean \pm SD (days)	5.9 \pm 2.9	5.3 \pm 1.4	NS
No., minor complications	8	12	NS
No., major complications	9	1	<0.05
No., with use of intravenous form analgesic	12	6	NS

NS = not significant; ANC = absolute neutrophil count.

Table 4 The minor and major complications of open versus laparoscopic appendectomy in each stage of appendicitis.

Parameters	Simple appendicitis		Perforated appendicitis		Appendicitis with abscess	
	OA	LA	OA	LA	OA	LA
Minor complications, No. (%)						
Abdominal distension / vomiting or paralytic ileus	3 (100)	3 (42.9)	7 ^{*,†} (77.7)		7 (87.5)	11 (91.7)
Development of an antibiotic-related rash		1 (14.2)	1 (11.1)			
Suture granuloma			1 [*] (11.1)		1 (12.5)	
Outpatient evaluation of complaints of nausea / vomiting, fever, pain or diarrhea		3 (42.9)	2 [†] (22.2)			1 (8.3)
Total number of minor complications	3	7	9	0	8	12
Major complications, No. (%)						
Wound infections	1 (100)	1 (50)	4 (80)	2 (33.3)	5 (55.6)	1 (100)
Intra-abdominal abscess					1 (11.1)	
30-day readmission for evaluation of complaints of nausea/vomiting, fever, pain, diarrhea or adhesive ileus		1 (50)	1 (20)	4 (66.7)	3 (33.3)	
Total number of major complications	1	2	5	6	9	1

The number in brackets shows the percentage of minor or major complications in OA group of that stage.

* Abdominal distension and suture granuloma occurred in the same patient among these patients in this group.

† Abdominal distension and outpatient evaluation of complaints of abdominal pain occurred in the same patient among these patients in this group.

laparoscopic appendectomy group, the removal of appendix or irrigation with normal saline was mainly via a port instead of the incision wound. Some authors think it could decrease the potential risk of wound contamination that may occur with an open procedure.^{20–22}

Additionally, in this study, there were more patients with postoperative intra-abdominal abscess formation in the OA group ($n = 1$) than that in the LA group ($n = 0$) in management of appendicitis with abscess (Table 3). This result differed from those from other published studies.^{4,6,7} The patient's nutritional status, immunity, and preoperative bacterial amount of appendicitis should be considered among the several factors contributing to intra-abdominal abscess in addition to the type of surgical procedure. However, there were too few patients with postoperative intra-abdominal abscess formation in this study to draw conclusions about whether or not there was potential risk of this complication in the OA or LA group.

Many studies have tried to address the question of whether LA is appropriate or even preferred for children with perforated appendicitis. The largest series is from the Children's Hospital of San Diego.¹¹ They reported their results for both simple and perforated appendicitis over 6 years, during which time they were transitioning from OA to LA. Postoperative abscess rates and incidence of bowel obstruction (major complications) did not differ between LA and OA in either group. But the investigators did not mention minor complications. In another study, they found wound infections and ileus complicating the postoperative

course of patients after laparoscopic appendectomy less frequently than after open appendectomy, though no difference in the rate of postoperative intra-abdominal abscesses exists between laparoscopic and open appendectomy for perforated appendicitis.²³

In summary, we have provided our experience, showing that laparoscopic appendectomy is as safe as an open appendectomy in all stages of pediatric appendicitis. Furthermore, there were fewer minor complications in the LA group in the management of perforated appendicitis and fewer major complications in the LA group in the management of appendicitis with abscess. Therefore, LA may be considered a better alternative technique to OA in the management of complicated appendicitis in children, including perforated appendicitis and appendicitis with abscess.

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